

Echinoids of the Kairuku Formation (Lower Pliocene), Yule Island, Papua New Guinea: Spatangoida

I.D. LINDLEY

Department of Geology, Australian National University, Canberra, A.C.T. 0200

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Spatangoid echinoids are well represented in the rich and diverse echinoid fauna of the Lower Pliocene Kairuku Formation, Yule Island, Papua New Guinea. Five taxa are recognised, including the schizasterid *Schizaster* (*Schizaster*) *alphonsei* sp. nov., the palaeostomatid *Palaeostoma kairukuensis* sp. nov., the brissid *Eupatagus* (*Eupatagus*) *pulchellus* (Herklots) and the spatangids *Maretia planulata* (Lamarck) and *Maretia cordata* Mortensen, 1948. The spatangoids, by comparison with the clypeasteroids and regularia, exhibit a high degree of endemism.

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KEYWORDS: Echinoidea, Spatangoida, *Schizaster*, *Palaeostoma*, *Eupatagus*, *Maretia*, Lower Pliocene, Papua New Guinea.

INTRODUCTION

This paper, describing spatangoid or burrowing echinoids, is the fourth in a series (Lindley 2001, 2003a, 2003b) on the rich and diverse echinoid fauna of the Kairuku Formation, Yule Island, Central Province, Papua New Guinea (PNG). Two new species are described and the spatangoids, by comparison with the clypeasteroids (Lindley 2003a) and regularia (Lindley 2003b), exhibit a high degree of endemism. The present descriptions are based on collections made by the writer in January 2002, and the reader is referred to Lindley (2003a) for locality details. Some specimens have been temporarily allocated Department of Geology, Australian National University repository numbers, pending their repatriation to PNG at the conclusion of studies, where they will be housed in the Department of Geology, University of Papua New Guinea, Port Moresby. The classification used herein follows that of Fischer (1966) and A.M. Clark and Rowe (1971).

SYSTEMATIC PALAEOLOGY

Class ECHINOIDEA Leske, 1778
Subclass EUECHINOIDEA Bronn, 1860
Superorder ATELOSTOMATA Zittel, 1879
Order SPATANGOIDA Claus, 1876

Suborder HEMIASTERINA Fischer, 1966
Family SCHIZASTERIDAE Lambert, 1905
Genus SCHIZASTER L. Agassiz, 1836

Type species

Schizaster studeri Agassiz, 1836, by subsequent designation of ICZN, 1948.

Diagnosis

Test small to large with anterior ambulacrum and frontal notch shallow to deep. Apical system located posterior of centre, with 2-4 genital pores. Anterior ambulacrum shallow to deep with pore pairs oblique or transverse and arranged in single or irregular, double rows. Anterior petals long and almost straight although at times distally flexed; at least twice the length of the posterior petals. Both peripetalous and lateroanal fascioles present and complete (McNamara and Philip 1980a, 1980b).

Subgenus SCHIZASTER L. Agassiz, 1836

Type species

See above.

Diagnosis

Moderate to large species of *Schizaster* with deep anterior notch. Anterior ambulacrum deep and long; pore pairs almost transversely oriented and in

single rows. Anterior petals long, deep and flexed; diverging at a low angle usually less than 80° (McNamara and Philip 1980a).

Schizaster (Schizaster) alphonsei sp. nov.

Figs 1a-c

Synonymy

Brisaster latifrons (A. Agassiz, 1898), Lindley 2001, p. 135.

Diagnosis

A small species of *Schizaster* with a relatively low test; apical system is 54 percent of test length from anterior. Anterior ambulacrum broad posteriorly, narrowing anteriorly, very deep, partially overhung by its sides, with the adjoining interambulacra forming narrow vertical keels; anterolateral ambulacra also incised, with sides partially overhung; moderately deep frontal sinus.

Etymology

Named for Alphonse Aisi of Yule Island, Central Province, PNG.

Description

Test of small size, elongate oval, only specimen with length x width x height measuring c. 36.5 x 30 x 17 mm. Test rather low, vertex located 54 percent of test length from anterior; the test slopes very gradually towards the anterior end; details of posterior end unknown. Oral surface gently convex.

Apical system located at vertex, slightly posterior of centre; number of genital pores unknown. Frontal ambulacrum broad posteriorly, but becomes noticeably narrower anteriorly; very deeply sunken, with sides partially overhung. Adjoining interambulacra forming narrow vertical keels. Frontal ambulacrum passes to a moderately deep frontal notch. Pore pairs arranged in a single row. Anterior petals sunken with sides partially overhung; petals are gently curved. Posterior petals short, closed and sunken. Posterior interambulacrum forming a prominent keel. Details of periproct unknown.

Peristome close to anterior end of test, shallowly sunken, with the sunken peristomal region continuing directly to frontal notch. Peripetalous fasciole well developed; a lateral fasciole passes posteriorly to meet with an anal fasciole that is partially preserved in F 1179. Both oral and aboral surfaces with a uniform covering of tubercles.

Remarks

Schizaster (Schizaster) alphonsei sp. nov. can be distinguished from *Schizaster excavatus* Jeannel and

R. Martin, 1937, Middle Pliocene, Java, by its shorter frontal ambulacrum and anteriorly positioned apical system (54 percent of test length from anterior compared with 65 percent, respectively). Jeannel and R. Martin (1937) described two specimens of *S. excavatus*, with length x width x height measuring 47 x 36 x 24 mm and 56 x 45 x 30 mm. This species and *S. (S.) alphonsei* both have low tests and a very deep frontal ambulacrum, wide at its posterior end, narrower anteriorly. *Schizaster (Schizaster) alphonsei* is readily distinguished from *Schizaster (Schizaster) aff. compactus* Koehler, 1914, described from the Middle Miocene of Barrow Island, northwestern Australia, by McNamara and Kendrick (1984), by the latter's possession of a smaller (length of 30 mm), globose test and shallow frontal notch. *Schizaster (Schizaster) sphenoides* Hall, 1907, redescribed by McNamara and Philip (1980a) from the Middle Miocene of Victoria, is similar to *S. (S.) alphonsei*, with a very deep frontal ambulacrum with overhung sides. However, this temperate water species can be distinguished from *S. (S.) alphonsei* by its large, subcircular test.

McNamara and Philip (1980a) described the progressive morphological changes in schizasterid echinoids from the Palaeocene to Recent, reflecting adaptation to the occupation of new ecological niches, and noted the following general trends:

(a) the posterior migration of the apex and apical system, allowing more water to flow over the anterior edge of the test toward the peristome;

(b) an increase in declination of the anterior slope, also increasing the flow of water to the anterior;

(c) lengthening of the test, allowing a further posterior migration of the apex and apical system; and

(d) lengthening and deepening of the frontal ambulacrum and the anterior notch, assisting in channelling water to the peristome.

McNamara and Philip (1980a) believed that these morphological adaptations in *Schizaster* were related to the need to enhance the current flow over the aboral surface of the test in a sediment of low permeability. These changes were considered by McNamara and Philip (1980a) to reflect adaptation to deeper burrowing and the occupation of finer sediments and were at their 'extreme' with the *Schizaster* morphotype during the Miocene.

The Lower Pliocene *S.(S.) alphonsei* is an intermediate form transitional between McNamara and Philip's (1980a) *Paraster* form, a sand-dwelling echinoid, and the *Schizaster* form, a mud-dwelling form. The echinoid's small test size, with an apical system slightly posterior of centre, short frontal ambulacrum and gentle anterior slope from the apex are typical of *Paraster* Pomel, 1869. A very deep frontal ambulacrum with a deep frontal notch is typical of the



Figure 1. *Schizaster (Schizaster) alphonsei* sp. nov. Lower Pliocene, Yule Island, Central Province. 1a-c, UPNG F1179, aboral, lateral and oral views. Bar scale = 1.0 cm. *Palaeostoma kairukuensis* sp. nov. Lower Pliocene, Yule Island, Central Province. 1d-f, UPNG F1186, aboral, lateral and posterior views. Bar scale = 0.5 cm; 1g, UPNG F1186, detail of apical system with elevated processes separating pore pairs, visible along the margins of the frontal ambulacrum (refer to Fig. 2 for an interpretation of frontal ambulacrum). Bar scale = 0.25 cm; 1h, UPNG F1186, view of pentangular peristome. Bar scale = 0.5 cm; 1i, ANU 60635, view of pentangular peristome. Bar scale = 0.5 cm.

Schizaster morphotype.

Material

Holotype UPNG F1179, a near complete test collected by R. Perembo from locality 24 of Francis et al. (1982) = locality 8280-3. Northwest of Aru're village, east coast of Yule Island, Central Province, PNG. Kairuku Formation, Lower Pliocene.

Family PALAEOSTOMATIDAE Lovén, 1867

Remarks

Family Palaeostomatidae differs from the Hemiasteridae in possessing a pentangular, rather than labiate, peristome (Mortensen 1950; Fischer 1966).

Genus PALAEOSTOMA Lovén in A. Agassiz, 1872

Synonymy

Leskia Gray, 1851, p. 134.

Skouraster Lambert, 1937, p. 89.

Type species

Leskia mirabilis Gray, 1851, p. 184.

Emended diagnosis

Test small, ovoid, inflated. Apical system central, or nearly so, 2 genital pores; paired ambulacra broadly petaloid, closed distally; frontal ambulacrum non-petaloid with pores arranged in a single radial row.

Remarks

The emended diagnosis for *Palaeostoma* is broadened from those presented by Mortensen (1950) and Fischer (1966), to include the Lower Pliocene species from Yule Island, strikingly similar in all characters except pore shape and placement in the frontal ambulacrum.

***Palaeostoma kairukuensis* sp. nov.**

Figs 1d-i, 2

Synonymy

Hemiaster sp., F. Chapman in Mayo et al. 1930; F. Chapman and I. Crespin in Montgomery 1930, p. 57; Lower Pliocene, Yule Island.

Ditremaster sp., Lindley 2001, p. 133; Lower Pliocene, Yule Island.

Diagnosis

A relatively large species of *Palaeostoma* with a little marked frontal ambulacrum; pores positioned adapically, arranged in a single radial row, 6-7 pore

pairs per row; pores small, circular, each pore pair separated by an elevated process of rectilinear shape.

Etymology

Named after Kairuku, the former Government Station and present village, southeast coast of Yule Island, Central Province, PNG.

Description

Test small, ovoid outline and high vaulted; the largest F1185, a slightly deformed test, with a length x width x height measuring 25 x 20 x c. 11 mm and the smallest ANU 60635 c. 14 x 11 x 8 mm. Vertex subcentral, about 52-60 percent of test length from anterior; test slopes both posteriorly and anteriorly from vertex, with an abrupt steepening near margins. Oral surface is convex.

Apical system located at vertex, ethmophract with madreporite not separating posterior oculars; two genital pores on top of conical elevations. Frontal ambulacrum non-petaloid, sunken posteriorly but flush and little marked anteriorly; frontal sinus very shallow. Pores of frontal ambulacrum are intra-fasciolar, arranged in a single radial row, 6-7 pore pairs per row; pores small, circular. Each pore pair oriented obliquely to line of radial row, pointing perradially distally; separated by an elevated process of rectilinear shape (Fig. 2). Ornament of frontal ambulacrum consists of sparse, irregular granules confined to margins of ambulacrum. Paired ambulacra straight, broad, closed distally, and sunken; posterior petals about 1/3 size of anterior ones. Pores are slit-like, equi-sized; adjacent pore-pairs are separated by 4-5 secondary tubercles. Interporiferous zone, narrow, naked.

Interambulacral areas within the peripetalous fasciole with a covering of fine primary tubercles with prominent bosses, set in a dense covering of granules; a particularly dense clustering of primary tubercles is present in interambulacral areas flanking the pore zone of the frontal ambulacrum. Otherwise, plates of aboral and oral surface with a scattered covering of primary tubercles with prominent bosses and granules, increasing in density towards anterior end of test.

Peristome distinctly pentangular, clearly evident in F1186 and ANU 60635. Periproct circular, located at upper end of curved posterior. Peripetalous fasciole very well marked on F1186; no other fascioles.

Remarks

Palaeostoma Lovén in A. Agassiz, 1872 is a locally common extant genus of the Indo-Pacific (Mortensen 1950; A.M. Clark and Rowe 1971). *Palaeostoma mirabile* (Gray), regarded as a primitive spatangoid, is particularly common in the Java Sea and is known to occur in the Philippine islands, south Japan,

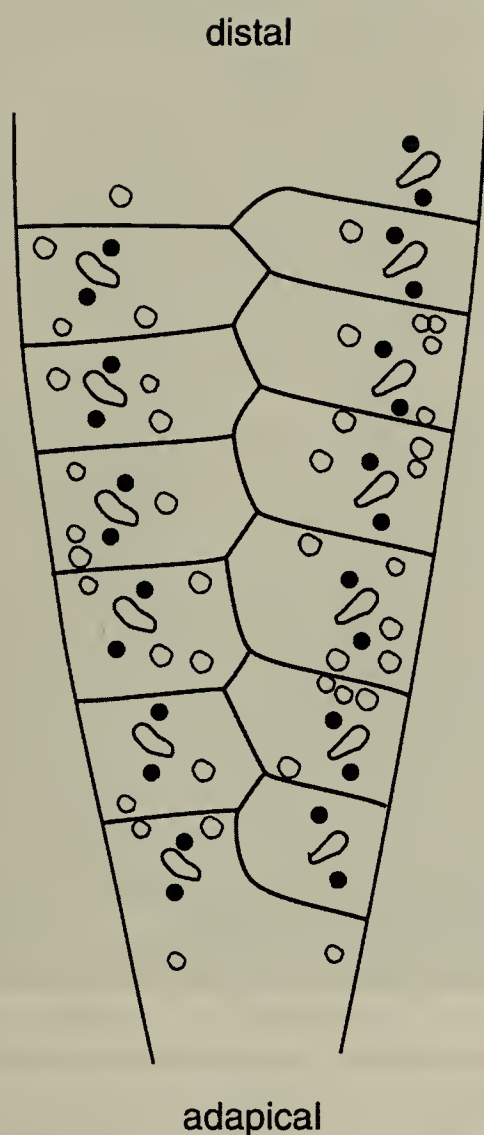


Figure 2. *Palaeostoma kairukuensis* sp. nov. Lower Pliocene, Yule Island, Central Province. Anterior ambulacrum (Amb III) showing pores arranged in a single radial row and pore pairs separated by an elevated process. Plate boundaries are interpretative.

the Indian Ocean, South Pacific islands and the Red Sea (Mortensen 1950; A.M. Clark and Rowe 1971). The maximum test size recorded by Mortensen (1950) was 18 mm length. *Palaeostoma mirabile* lives in mud and has a bathymetric distribution of c. 20-110 m (Mortensen 1950). Only two fossil species have been recorded, *Palaeostoma zitteli* de Loriol, 1881 and *Palaeostoma rochi* Lambert, 1937, from the Eocene of Egypt and Morocco, respectively (Mortensen 1950). Both Eocene forms have distinctive frontal depressions and are clearly not related to the Lower Pliocene species from Yule Island.

Eocene species of *Palaeostoma* and *P. mirabile* are distinguished by their possession of a frontal

ambulacrum with pores arranged in a single radial row, the distal one of each pair comma-shaped. In the frontal ambulacrum of *P. kairukuensis* sp. nov. (F1186, measuring 20 mm length), each radial row possesses 6-7 pore pairs, each pore being small and circular. Although Mortensen (1950) and Fischer (1966) did not state the number of pore pairs in the frontal ambulacrum of *P. mirabile*, an illustrated specimen in Mortensen (1950: Plate V, Fig. 4; reproduced in Fischer 1966: Fig. 451) indicates 8-9 pore pairs in each radial row. This specimen measures 15 mm length. The frontal ambulacrum of *P. kairukuensis* is flush at the ambitus, indicating that the entire structure was unlikely to be involved in food gathering and transportation (Smith 1984). The pores of the frontal ambulacrum are all intra-fasciolar, located adapically in a sunken region of the ambulacrum high on the dorsal side of the test. A dense cluster of primary tubercles is present in the flanking interambulacra.

The presence of pore pairs in the adapical region of the frontal ambulacrum, as opposed to the ambital region, indicate that funnel-building tube feet were present (Nichols 1959; Smith 1984). Normally, each pore of a pair gives passage to a tube foot connected internally to its ampulla, and the more perradial pore is grooved to house a branch of the radial nerve (Fischer 1966; Smith 1984). A rimmed area surrounding each pore is an attachment area for the stem retractor muscle, and the width of this area gives a measure of the thickness of the stem retractor muscle and hence an idea of the strength of the tube foot (Smith 1984: 41). These tube feet, typical of the dorsal region of burrowing spatangoids, were primarily engaged in building and maintaining a long open respiratory funnel to the sediment/water interface (Nichols 1959; Durham 1966). The prominent elevated process separating pore pairs in the frontal ambulacrum of *P. kairukuensis* (Fig. 2) may have been an attachment structure for the stem retractor muscle, its small surface area interpreted to indicate tube feet of limited length. Nichols (1959: Figs 41 and 45) figured and described a similar process between pore pairs of ambulacra I and II of *Micraster coranguinum* Leske, 1778, interpreting it as a muscle attachment feature.

Palaeostoma kairukuensis, with its poorly developed frontal ambulacral pore pairs, was probably a shallower burrower than *P. mirabile*. The relatively dense covering of aboral tubercles and the presence of a well developed peripetalous fasciole on the test of the Yule Island species also indicate not only an infaunal mode of life, but also burrowing in fine sands and muds (Smith 1984).

Material

Holotype UPNG F1186, a near complete test;

and paratypes UPNG F1185, a deformed test, collected by R. Perembo from locality 24 of Francis et al. (1982) = locality 8280-3; and ANU 60635-36, two worn specimens, from locality 8280-3. Locality 8280-3 is northwest of Aru're village, east coast of Yule Island, Central Province, PNG. Kairuku Formation, Lower Pliocene.

Suborder MICRASTERINA Fischer, 1966
Family BRISSIDAE Gray, 1855
Genus EUPATAGUS L. Agassiz, 1847

Synonymy

Pseudopatagus Pomel, 1885, p. 18.
Melitia Fourtau, 1913, p. 68.
Heterospatangus Fourtau, 1905, p. 606.
Euspatangus Cotteau, 1869, p. 257.
Perispatangus Fourtau, 1905, p. 605.
Koilospatangus Lambert, 1906, p. 185.
Zanolettiaster Sánchez Roig, 1952, p. 14.
Megapatagus Sánchez Roig, 1952, p. 58.

Type species

Eupatagus valenciennesi L. Agassiz, 1847, by subsequent designation of Pomel, 1883, p. 28; Recent, Australia.

Diagnosis

Test ovoid in outline, low, oral side flat; apical system anterior, ethmolytic, with 4 genital pores; paired ambulacra with closed petals; frontal ambulacrum nonpetaloid, pores in single series; primary tubercles on aboral side only within peripetalous fasciole (Fischer 1966).

Subgenus EUPATAGUS L. Agassiz, 1847

Type species

See above

Diagnosis

Ambitus rounded, frontal sinus weak or absent (Fischer 1966).

***Eupatagus (Eupatagus) pulchellus* (Herklots)**
Figs 3a-e

Synonymy

Spatangus pulchellus Herklots, 1854, p. 12; Miocene, Java.
Hemipatagus pulchellus, Desor, 1858, p. 418.
Maretia? pulchella, K. Martin 1880, p. 5; Gerth 1922, p. 512; Miocene, Java.
Brissoides (Brissoides) pulchellus, Lambert

and Thiéry 1924, p. 451.

Maretia pulchella, Lambert and Thiéry 1924, p.451

Eupatagus pulchella, F. Chapman and I.

Crespin in Montgomery 1930, p. 57; Lower Pliocene, Yule Island.

Eupatagus (Brissoides) pulchellus (Herklots), Jeannet and R. Martin 1937, p. 273; Miocene, Java.

Eupatagus pulchellus (Herklots), Mortensen 1951, p. 472, 473; Miocene, Java.

Description

Test of small size, elongate oval, the largest ANU 60603 measuring 40 x 34.5 x 18 mm, and the smallest, ANU 60616, 27 x 25 x 14 mm. Test low, vertex located centrally; test slopes very gently towards anterior end, with an abrupt steepening near margin; test slopes gently towards posteriorly, to an abrupt vertical termination. Oral surface is gently convex.

Apical system located anteriorly of vertex, at about 37 percent of test length from anterior; four genital pores. Frontal ambulacrum non-petaloid, narrow, not sunken, with a very shallow frontal sinus. Paired ambulacra closed petaloid, weakly sunken. Outer and inner pores of pore pairs are equi-sized; consecutive pore pairs are separated by a rounded transverse ridge and, adapically, a shallow transverse depression. Interporiferous zone covered by randomly arranged secondary tubercles and numerous miliary tubercles.

Posterior interambulacrum V is developed into a prominent keel with irregularly arranged secondary tubercles and numerous miliary tubercles. The paired interambulacra have 4-7 large, perforate, crenulate tubercles within the peripetalous fasciole. Otherwise, the plates of the aboral side with dense covering of secondary and miliary tubercles.

Peristome is large, transversely elliptical, without a prominent lip. Periproct is pear-shaped, situated high up on the vertical posterior end of test, with the point of it just visible in aboral view. Plastron is distinctly inflated particularly in juvenile specimens (ANU 60616), which bear a high, medial keel.

Peripetalous fasciole is difficult to recognise in many specimens; however, in ANU 60608 fasciole is distinct, passing around adoral extremity of petals of paired ambulacra, before disappearing towards frontal ambulacrum. Subanal fasciole present.

Remarks

Eupatagus (Eupatagus) pulchellus (Herklots) is locally very common in the lower to middle Kairuku Kormation. The species appears to be identical in all respects to the specimen figured by Jeannet and R.

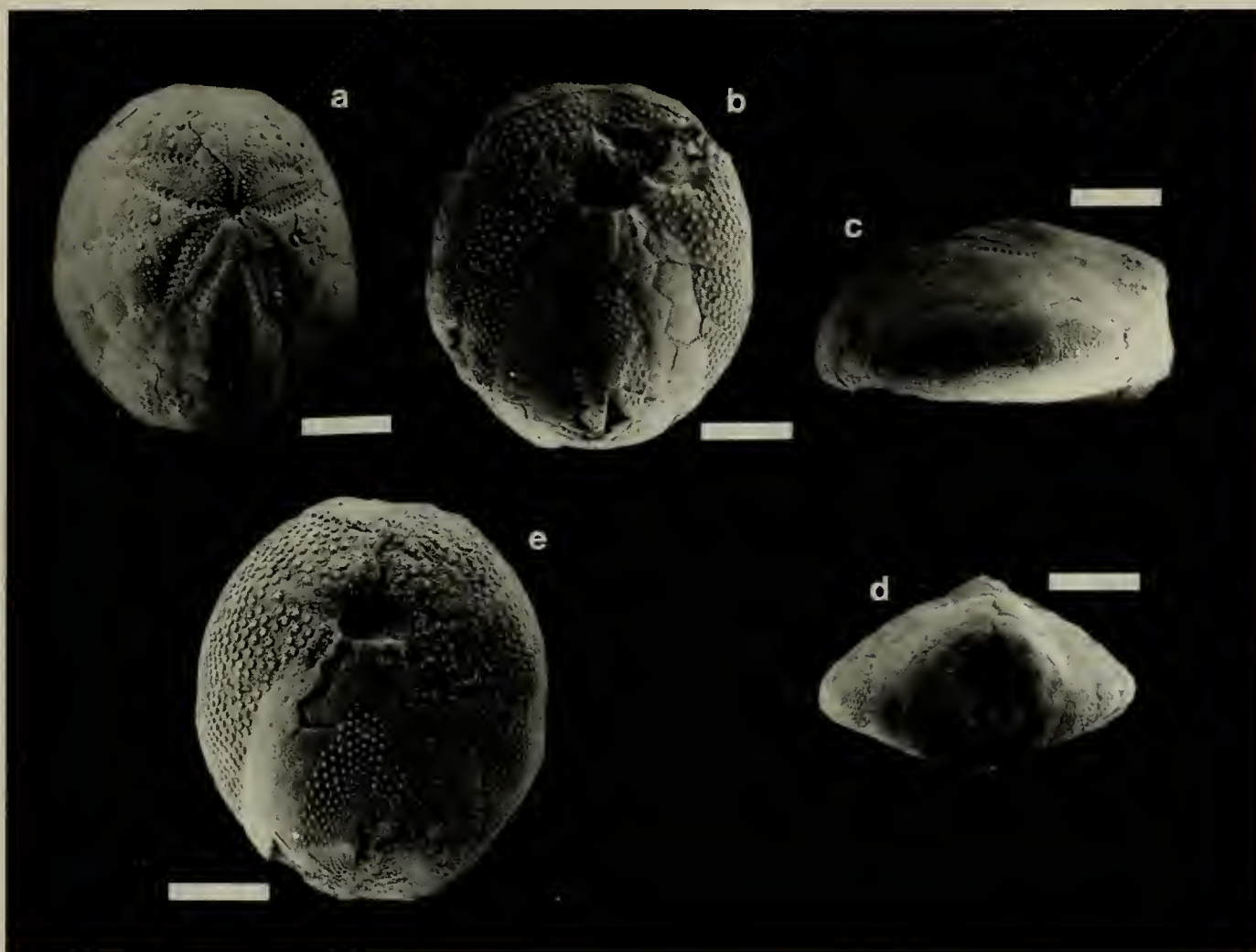


Figure 3. *Eupatagus (Eupatagus) pulchellus* (Herklots). Lower Pliocene, Yule Island, Central Province. 3a-d, ANU 60603, aboral, oral, lateral and posterior views. Bar scale = 1.0 cm; 3e, ANU 60607, oral view. Bar scale = 1.0 cm.

Martin (1937: Figs 50a, b) from the Miocene of Java. The largest of the four specimens described by Jeannet and R. Martin (1937) has dimensions of 40.9 x 35.3 x 23.0 mm and the smallest 33.5 x 29.0 x >20 mm. The difficulty in proving the presence of a peripetalous fasciole in the specimens described and figured by Herklots (1854) led to uncertainty in referral to *Eupatagus* L. Agassiz, 1847 (Mortensen 1951). However, Jeannet and R. Martin (1937) proved the existence of a peripetalous fasciole and Mortensen (1951) believed there was little doubt that the East Indies form is an *Eupatagus*.

Mortensen (1951: 472) considered *E. (E.) pulchellus* to be a near relation of the extant *Eupatagus (Eupatagus) rubellus* Mortensen, 1948. The only known specimen of this species was collected near Tinakta Island of the Tawi Tawi group (5° 12'N; 119° 55'E), Sulu Archipelago, Philippines, at a depth of 24 m (Mortensen 1948b). Many examples of *E. (E.) pulchellus*, preserved in a range of orientations, were collected from the middle Kairuku Formation at

locality 8280-4, north of Aru're village on the east coast of Yule Island. This shallow-water sequence was interpreted by Lindley (2003a) to have suffered wholesale disruption and redistribution of sediment resulting from a succession of large storm events.

Material

Twenty-nine complete tests including: ANU 60608, 60611 from locality 8280-2; ANU 60612 from locality 8280-3; and ANU 60603, 60607, 60609-10, 60613-34 from locality 8280-4. All localities are on the east coast of Yule Island, Central Province, PNG. Kairuku Formation, Lower Pliocene.

Family SPATANGIDAE Gray, 1855

Genus MARETIA Gray, 1855

Synonymy

Hemipatagus Desor, 1858, p. 416.

Tuberaster Peron and Gauthier, 1885, p. 46.

Thrichoproctus A. Agassiz (M.S. *nom. nud.*).
Plagiopatagus Lütken (in *litteris*, *nom. nud.*).

Type species

Spatangus planulatus Lamarck, 1816, p. 326,
 by original designation; Recent.

Maretia planulata (Lamarck)
 Fig. 4d

Synonymy

Spatangus planulatus Lamarck, 1816, p. 326.
Spatangus praelongus Herklots, 1854, p. 11;
 Miocene, Java.
Spatangus affinis Herklots, 1854, p. 10;
 Miocene, Java.
Maretia planulata Gray, 1855, p. 48; Tenison-
 Woods 1878, p. 173: Recent, Australia;
 Tenison-Woods 1881, p. 204: Recent,
 Australia; Gerth 1922, p. 512: Pliocene,
 Java; Jeannet and R. Martin 1937, p. 277:
 Miocene, Java; Mortensen 1951, p. 21;
 A.M. Clark and Rowe 1971, p. 146:
 Recent, northern Australia; Gibbs et al.
 1976, p. 135: Recent, Low Isles, northern
 Great Barrier Reef; De Ridder 1986, p. 48:
 Recent, New Caledonia.
Maretia ?planulata, K. Martin 1885, p. 286:
 Miocene, Java.
Maretia ovata, H.L. Clark 1932, p. 277; H.L.
 Clark 1946, p. 380: Recent, northern Great
 Barrier Reef.
 T. Mortensen (1951), A Monograph of the
 Echinoidea 5(2), Spatangoida II, p. 27-29,
 lists the previous synonymies.

Description

Test of moderate size, very low, only specimen
 measuring 44 x c. 50 x c. 10 mm, length:height in
 the range of 3-4:1 of A.M. Clark and Rowe (1971); low
 arched above, with moderately sharp edges; outline
 elongate oval. Anterior notch apparently lacking,
 although test is broken in this region. Oral side is gently
 concave about a medial line passing posteriorly through
 frontal ambulacrum.

Details of apical system unknown. Frontal
 ambulacrum flush and indistinct. Pore pairs are
 indistinct. Anterior petals flush, straight and closed
 distally; interporifeous zone is broad, conspicuously
 raised, densely covered with fine miliary tubercles and
 occasional irregularly placed secondary tubercles.
 Details of posterior petals unknown.

Details of periproct and peristome unknown.
 Details of subanal fasciole unknown. The aboral

surface between paired petals and frontal ambulacrum
 with large primary tubercles arranged in horizontal
 series. Tubercles are perforate, crenulate, with
 moderately sunken aureoles. Anterolateral margins of
 test with dense covering of secondary tubercles. Oral
 surface with uniform covering of distinctively shaped
 tubercles, best described (and figured) by Mortensen
 (1951; 33 and Fig. 14), with 'the boss forming a screw,
 and the aureole unequally deepened, the whole
 structure almost resembling an ear'.

Remarks

ANU 60606, an incomplete test lacking details
 of the posterior, peristome and apical system, is
 assigned to *Maretia planulata* (Lamarck) on the basis
 of test shape, tubercle arrangement on the aboral
 surface and the distinctive shape of tubercles on the
 oral surface. As fossil, *M. planulata* has been recorded
 from the Pliocene of the Red Sea region and Zanzibar,
 and the Mio-Pliocene of Java (Mortensen 1951; Jeannet
 and R. Martin 1937). Extant forms of the species are
 widely distributed throughout the tropical-subtropical
 Indo-West Pacific, from East Africa (Mozambique,
 Madagascar), northern Australia, China and southern
 Japan, and Fiji and the Gilbert Islands (Mortensen
 1951; A.M. Clark and Rowe 1971). On the Australian
 coast the species occurs from Cooktown southward to
 Port Jackson, but not from within, or to the west of,
 the Torres Strait region (H.L. Clark 1946). The
 spatangoid lives buried in muddy sand within the ebb
 zone and often comes to the sand surface during
 exposure on day-time spring tides (Mortensen 1951;
 Gibbs et al. 1976). Mortensen (1951) records the
 species to a depth of c. 60m.

Material

ANU 60606, a fragmentary test including left
 anterior petal and frontal ambulacrum, from locality
 8280-1, south of Tete ne'ina Beach, east coast of Yule
 Island, Central Province, PNG. Kairuku Formation,
 Lower Pliocene.

Maretia cordata Mortensen, 1948
 Figs 4a-c

Synonymy

Maretia cordata Mortensen, 1948, p. 132;
 Mortensen 1951, p. 41: Recent, East Indies.

Description

Test small, distinctly heart-shaped, aboral side
 low arched, not flattened. ANU 60604, slightly
 deformed at its right-anterior end, has a length x width
 x height of 27 x 26 x 10 mm, similar to the largest of
 four specimens described by Mortensen (1951),

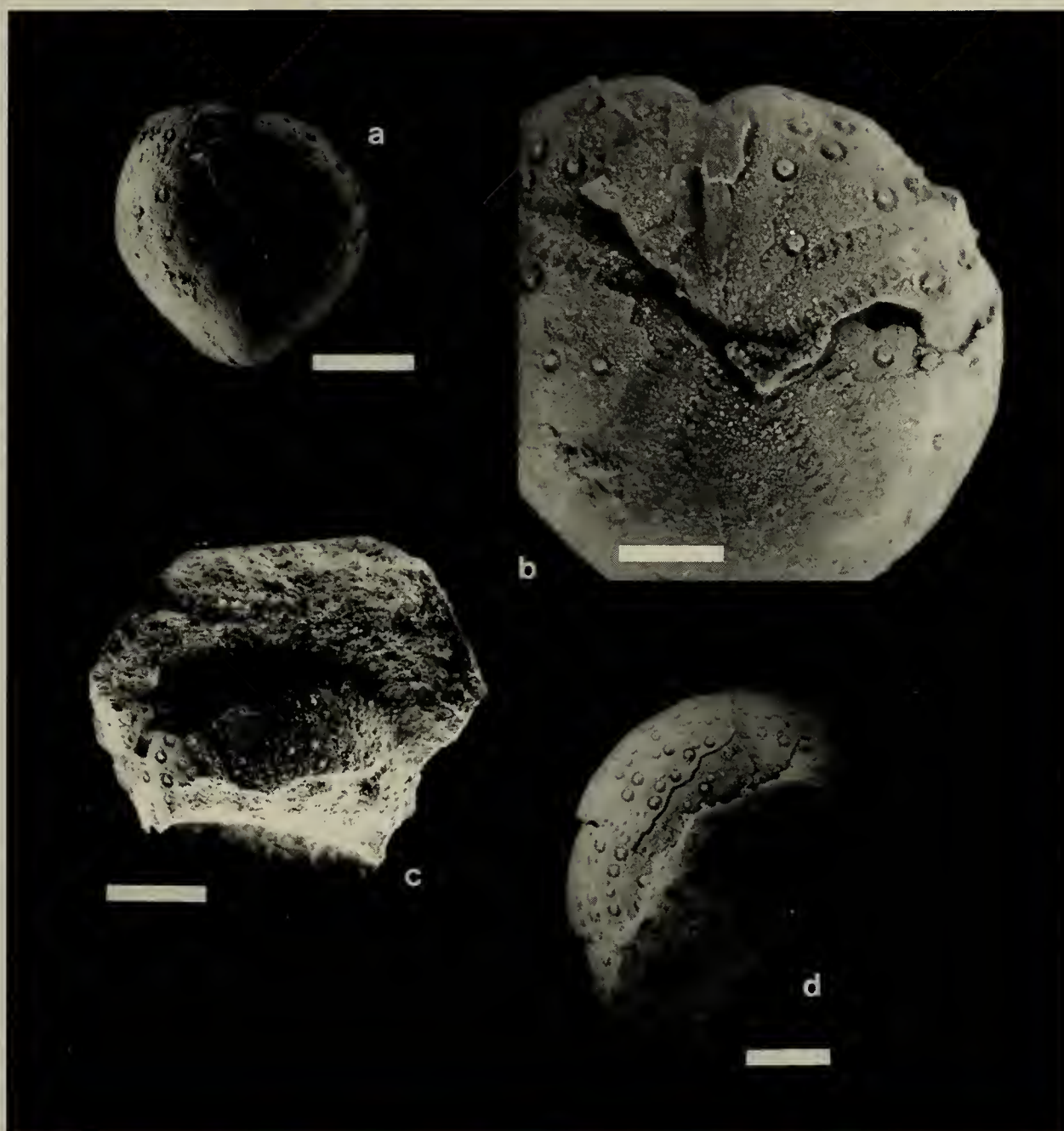


Figure 4. *Maretia cordata* Mortensen, 1948. Lower Pliocene, Yule Island, Central Province. 4a-b, ANU 60604, aboral view and detail of apical system showing anterior series of the right anterior petal (Amb II) with upper 4-5 plates with rudimentary pores or none. Bar scales = 1.0 and 0.5 cm respectively; 4c, ANU 60605, aboral view of incomplete specimen, with left anterior petal (Amb IV) visible. Bar scale = 1.0 cm. *Maretia planulata* (Lamarck). Lower Pliocene, Yule Island, Central Province. 4d, ANU 60606, aboral view of incomplete test, with left anterior petal (Amb IV) visible. Bar scale = 1.0 cm.

measuring 28 x 28 x 10 mm; ANU 60605, an incomplete specimen, is slightly larger than Mortensen's (1951) specimens with a width x height of 29 x 14 mm. Test slopes very gently both anteriorly and posteriorly from apical system, with an abrupt steepening near margins. Details of oral surface unknown.

Apical system located at about 44 percent of test length from anterior; number of genital pores unknown. Frontal ambulacrum distinctly sunken, pores

pairs indistinct, passing to a conspicuous frontal notch. Petals flush, closed distally. Anterior series of the anterior petals with upper 4-5 plates with rudimentary pores or none. Interporiferous zone is flat, with a sparse covering of miliary and some secondary tubercles. Details of periproct and subanal fasciole unknown.

Posterior interambulacrum V is raised forming a low keel that slightly overhangs the periproct; ornamentation consists of a sparse covering of fine miliary tubercles and some secondary tubercles. The

paired interambulacra each with 8-10 perforate, crenulate primary tubercles set amongst a sparse covering of miliary tubercles and occasional secondary tubercles; placement of primary tubercles is random with a tendency toward arrangement in horizontal series near the ambitus.

Details of peristome unknown.

Remarks

Maretia cordata Mortensen, 1948 was erected by Mortensen (1948b) to distinguish tests with a distinctly different shape, deeper frontal depression and broader petals than *M. planulata*. He recorded the species from Palawan Island, Philippines, and the Bali Sea and Flores Sea, Indonesia, at bathymetric ranges of 50-150 m. ANU 60604 and 60605 from the Pliocene of Yule Island, are referable to *M. cordata* on the basis of test size and shape, the presence of a distinct frontal depression and sinus, paired petals distinctly broader than *M. planulata*, and the nature of the anterior series of the anterior petals. Mortensen (1951) noted that large specimens of *M. cordata* carry some large tubercles in the posterior ambulacrum, but the Yule Island specimen ANU 60604, equal in size to the largest described by him, does not have primary tubercles in the posterior ambulacrum.

Mortensen (1951: 44) noted that *Hemipatagus bandaensis* R. Martin (in Jeannet and R. Martin 1937) from the (?) Pliocene of Banda, Indonesia, is a probable ancestor of *M. cordata*. The Pliocene record of *M. cordata* from Yule Island makes this unlikely. *Hemipatagus bandaensis* does not possess a raised keel in the posterior interambulacrum, and the posterior aboral surface curves gradually from the vertex towards margin, contrasting with the flattened-gently sloping surface of *M. cordata*.

Material

Two tests: ANU 60605, an incomplete test lacking posterior details from locality 8280-1, south of Tete ne'ina Beach, and ANU 60604, a complete, though slightly deformed test, from locality 8280-3, northwest of Aru're village, east coast of Yule Island, Central Province, PNG. Kairuku Formation, Lower Pliocene.

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